

REMARKS

In the Office Action, the Examiner rejected claims 1-34 under 35 USC 103. These objections and rejections are fully traversed below.

Claims 1, 17, 24, and 29 have been amended to correct minor informalities and to further clarify the subject matter regarded as the invention. Claims 16, 18, 20 and 26 have been cancelled and new claims 35-38 have been added. Claim 26, which is dependent upon claim 24, has been cancelled and rewritten into independent claim 24. Thus, claim 24 now includes all of the limitations of claim 24 as well as all of the limitations of claim 26. Accordingly, claims 1-15, 17, 19, 21-25 and 27-38 are pending in the application. Reconsideration of the application is respectfully requested based on the following remarks.

ISSUES UNDER 35 USC 103(a)

Claims 1- 4, 6, 8-34 have been rejected under 35 U.S.C. §103(a) as being unpatentable over the admitted Prior Art in view of Shan, et al (U.S. Patent No. 5,605,637) (Hereinafter Shan) and Walko, II (U.S. Patent No. 6,051,100) (Hereinafter Walko). Claims 5 and 7 have been rejected under 35 U.S.C. §103(a) as being unpatentable over the admitted Prior Art in view of Shan and Walko as applied to claims 1, 2, 4, 6, 9, 13, 14-34 above, and further in view of Tomoyasu, et al (U.S. Patent No. 5,900,103) (Hereinafter Tomoyasu).

The admitted prior art discloses a plasma reactor, a chamber wall, a top and bottom electrode, both of which are connected to an RF power supply, a teflon shroud and a confinement ring.

Shan discloses a plasma reactor including a plasma chamber having a wafer supporting lower electrode (or cathode) and an upper electrode (or anode), a plasma shield, and a chamber liner. The upper electrode is electrically continuous with the walls of the plasma chamber, which is grounded. As such, the anode is the entire grounded area of the upper electrode itself and the grounded walls of the chamber. The lower electrode is connected to an RF-generator, such that when RF power is applied to the lower electrode, a direct current bias is generated between the plasma and the lower electrode. The dc bias accelerates ions in the plasma into a semi-conductor wafer. The plasma screen, which blocks plasma from reaching a region of the chamber, includes

a number of slits, which are arcuate in length, and which provide a path for process gases. Circular holes may also be used. The plasma screen is formed from a dielectric material. Furthermore, the chamber liner covers a select portion of the inside walls of the chamber. The chamber liner is also formed from a dielectric material, although semi-conducting and conducting materials may also be used. Both the plasma screen and the chamber liner are used to reduce the dc bias on the lower electrode (cathode).

Walko discloses a plasma reactor including a chamber having a wafer supporting cathode, a side wall, a top lid, a manifold and a containment structure. The side wall, top lid and manifold are made from an electrically conductive material such as aluminum and are connected to ground. The cathode may be connected to an RF system such that when power is applied to the cathode, a plasma sustaining electromagnetic field is generated between the cathode and the chamber side walls and the manifold. Moreover, the containment plate is arranged for containing the plasma, which is sustained by an electromagnetic field, within a desired space in the chamber by attenuating the electromagnetic field in the chamber while maintaining high conductance across the plate (See generally Summary of Invention, Cols. 2 - 4). The containment plate also includes rings or openings to allow the passage of gas molecules through it. Walko states, "the containment plate is electrically conductive (e.g., anodized aluminum) and is electrically grounded and is used in a chamber that uses 13.56 MHz electromagnetic fields to sustain the plasma. A protective coating such as a thin ceramic may cover the plate to protect the plate. For the RIE chamber depicted herein, conductive rings form annular openings to attenuate the electromagnetic field...(See Col. 9, lines 18-24)."

Tomoyasu discloses a plasma reactor including a process chamber, an upper electrode, which is connected to a second oscillator, and a lower electrode, which is connected to a first oscillator. Tomoyasu also discloses frequencies of high frequency power applied to the upper and lower electrodes to generate a plasma. For example, Tomoyasu states, "It is preferable that the first frequency f_1 is set lower than 5 MHz, more preferably in a range of 100kHz-1MHz. It is also preferable that the second frequency f_2 is set higher than 10 MHz, more preferably in the range of 10 MHz-100MHz. More specifically, Tomoyasu states, "a first oscillator serves to oscillate high frequency signal having a frequency of 800 kHz (See Col. 5, lines 22-23)," and "a second oscillator serves to oscillate high frequency signal having a frequency of 27 MHz (See Col. 5, lines 37-37)."

Claim 1 and 24

In contrast to the combination of the admitted prior art, Shan and Walko, claims 1 and 24 of the present application require a plasma confinement ring, which is arranged for increasing the ion energy of the plasma. Claim 1 specifically requires, “said perforated plasma confinement ring being formed from a conductive material and electrically grounded during said processing **so as to increase ion energy during said processing.**” Claim 24 specifically requires, “said conductive ring being formed from a conductor...said conductive ring being electrically grounded during said processing...said conductive ring **removing electrons from said plasma and thereby increasing ion energy in said plasma.**” As should be appreciated, electrons are removed from the plasma at the grounded conductive confinement ring by forming a path for the electrons to flow to ground. A reduction in electrons tends to produce higher ion energies. Again, there is a need in plasma etching technology for etching with higher aspect ratios and etched profiles that are more vertical, both of which require higher ion energies.

While the combination of the admitted prior art, Shan and Walko may suggest a grounded conductive plasma containment shield and a chamber liner, none of the references teach or suggest increasing the ion energy. In fact, both Shan and Walko teach away from increasing the ion energy. For example, Shan states, “A high dc bias has the principal disadvantage that the highly energetic ions it produces tend to cause unwanted damage to the wafer being etched...(See Col. 1, lines 58-60),” “Clearly it would be desirable to have an etch reactor that could operate at a selected lower dc bias, to avoid the problems caused by the high dc bias...(See Col. 2, lines 16-18),” “In accordance with the invention, two structural elements are added to the etch reactor chamber to reduce the effective area of the anode 14 and the grounded wall surface 10, and thereby to reduce the dc bias on the cathode 12 (See Col. 4, lines 31-34),” and “The presence of the plasma shield reduces the effective surface area of the grounded upper electrode and thereby reduces the dc bias between the lower electrode and the plasma (Col. 3, line 7-11).” The two structural elements for reducing the dc bias are the chamber liner and the dielectric plasma screen. Since reducing the dc bias reduces the ion energy, the chamber liner and plasma screen (of Shan) are arranged to decrease ion energy. As such, the plasma shield of Shan is not the plasma confinement ring of the present invention.

Walko is less clear on this issue, however, Walko states, “...contain a plasma within a desired space in the chamber by attenuating the electromagnetic field generated in the chamber

(See Col. 3, lines 18-20).” As should be appreciated by the Examiner, attenuating is defined as weakening, and therefore the containment plate of Walko is designed to weaken the electromagnetic field. A weakened field reduces the sheath voltage, which as a result, reduces the ion energy. The containment plate (of Walko) is therefore also arranged to decrease ion energy. As such, the containment plate of Walko is not the plasma confinement ring of the present invention.

Furthermore, it is the applicant’s belief that all of the cited references completely fail to suggest increasing the ion energy in the plasma. For example, Tomoyaso states, “...In order to achieve such a finer workability...plasma density must be kept higher...high frequency voltage becomes higher as output is made larger, and ion energy, therefore, becomes stronger than needed. The semiconductor wafer becomes susceptible to damage, accordingly (See Col. 1, lines 14-22),” and “when the frequency of high frequency power is only made high to increase plasma density, the dissociation of gas molecules progresses to the extent greater than needed (See Col. 1, lines 56-58),” and “The generating and keeping of plasma itself are attained in this case by the high frequency power having a higher frequency and applied from the second power supply. Stable and high density plasma can be thus created (See Col. 9, lines 37-40).” The most that can be said is that the cited patents mention a plasma reactor and plasma containment structures that reduce the ion energy. In order for the cited references to render the claims obvious, at least one of the references would have had to teach increasing the ion energy.

Therefore, for at least the reasons above, it is respectfully submitted that the art of record neither discloses nor reasonably suggests the invention as currently recited in claims 1 and 24. Accordingly, it is respectfully submitted that claims 1 and 24, as amended, are patentable over the art of record.

Claims 2-15, 17, 19, 21-23, 25, and 27-34 each depend either directly or indirectly from claims 1 and 24 and are therefore respectfully submitted to be patentable over the art of record for least the reasons set forth above. They also require additional elements that when considered in light of the claimed combination further patentably distinguish the present invention. For example:

Claim 11

Claim 11 specifically requires, “ wherein the outer diameter of said perforated confinement ring is larger than an inner diameter of said insulating shroud.” In contrast, as shown in Fig. 1 of Shan, the plasma screen 30 is disposed between the insulating material 38 and the chamber liner 44. As should be appreciated, the outer diameter of the plasma screen 30 cannot be larger than the inner diameter of the chamber liner 44. Accordingly, it is respectfully submitted that claim 11 is patentable over the art of record.

Claim 13, 26 and 35-38

Although the Examiner has rejected Claim 13 and 26, the Examiner has not presented a reason for unpatentability. Claim 13 requires a conductive perforated confinement ring that is either substantially resistant to etching by a plasma present with the chamber during processing or contributes substantially no metal contamination. Claim 26 has been cancelled and rewritten into independent claim 24. Therefore, claim 24 now requires a conductive perforated confinement ring that is substantially resistant to etching by a plasma present with the chamber during processing. Furthermore, new independent claim 35 also requires the aforementioned feature. In one embodiment, the conductive perforated confinement ring is formed from SiC, which provides the aforementioned properties. New dependent claims 36-38, which are directed at the SiC embodiment, have been added. In contrast, Shan discloses a non-conductive dielectric plasma screen, while Walko discloses a conductive containment plate formed from anodized aluminum. Walko also discloses, “a thin ceramic may cover the plate to protect the plate,” however, there is no mention of a conductive plate that is substantially resistant to etching by a plasma present with the chamber during processing or contributes substantially no metal contamination. Furthermore, neither Shan nor Walko teach a plasma ring, which is formed from SiC. Accordingly, it is respectfully submitted that claim 13, 24 and new claims 35-38 are patentable over the art of record.

Claim 17 and 29

Claims 17 and 29 specifically require perforations that are slotted. By slotted, it is meant that the perforations extend across the width of the perforated plasma confinement ring or are substantially linear openings positioned radially relative to the center of the perforated plasma

ring (See Fig. 5b). As such, claims 17 and 29 have been amended to recite this limitation. In contrast, none of the cited references teach or suggest perforations that are slotted in this manner. Shan discloses slits that are arcuate in length and positioned concentrically or annularly. Shan also discloses circular holes (See generally, Col.4 & 5, lines 46-8 and Fig. 2). While Shan states, “the number, size and spacing of the openings, whether they are slits or holes, may also have an effect on the pump rate...(See Col. 5, lines 2-3),” Shan is silent to the effects of the slit position relative to the plasma screen. Similarly, Walko discloses annular openings 42 as shown in Figs. 5, 6, and 8. Accordingly, it is respectfully submitted that claims 17 and 29 are patentable over the art of record.

Claims 22, 23, 33 and 34

Claims 22 and 33 specifically require, “a percentage of open area of said perforated plasma confinement ring is above 20%,” and Claims 23 and 34 specifically require, “a percentage of open area of said perforated plasma confinement ring is about 50%. As stated in the specification, “the percentage of the open area in the perforated plasma confinement ring is a critical parameter. By way of example, a 20% open area yields unacceptable etch results while a 50% open area improves the etch profile (See page 12, lines 12-14).” None of the cited references teach a percentage of open area. The undersigned respectfully disagrees with the Examiner when the Examiner states that the percentage is obvious to modify the shape, size, depth and the percentage of the holes in order to optimize and improve the performance of the plasma containment. That is, the percentage of open area is an important factor for determining the exhaust rate, containing the plasma, and removing electrons. Using Walko as an example, Walko states repeatedly that the holes are configured to attenuate the electric field, and offers several different designs including sharp and rounded corners, holes with different angles, and holes with large and small aspect ratios (See Generally, Col. 9 – Col. 10). All of these designs are used to improve some aspect of etching. For example, a large aspect ratio is used to attenuate strong electromagnetic fields, while sharp corners reduce the tendency of deposits. Accordingly, it is respectfully submitted that claims 22, 23, 32, and 33 are patentable over the art of record.

Applicant believes that all pending claims are allowable and respectfully requests a Notice of Allowance for this application from the Examiner. Should the Examiner believe that a telephone conference would expedite the prosecution of this application, the undersigned can be reached at the telephone number set out below.

Respectfully submitted,

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